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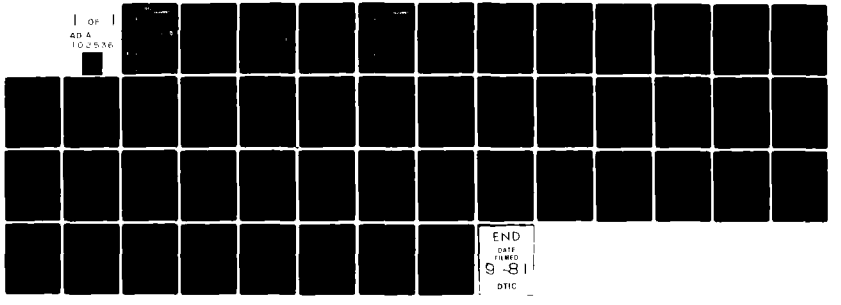

Special Report
80-3

HumRRO
SR-ETSD-80-3

HumRRO

Front-End Analysis to Aid Emerging Training Systems

WORKSHOP SUMMARY

by

R.J. Seidel and H. Wagner

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

February 1980

Prepared for:

Defense Advanced Research Projects Agency

Under:

Contract MDA 903-78-C-0023

HUMAN RESOURCES RESEARCH ORGANIZATION

Office of the President
300 North Washington Street
Alexandria, Virginia 22314
(703) 549-3611

July 24, 1981

Dr. Dexter Fletcher
US Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, Va. 22314

Dear Dr. Fletcher:

Back in September 1979, under your aegis, HumRRO conducted a workshop on "Front-End Analysis to Aid Emerging Training Systems." We produced a workshop summary report by Bob Seidel and Hal Wagner in February 1980, but never asked for "open release clearance."

At the NSIA conference in San Diego last May, you invited attendees at one of your seminars to contact HumRRO for copies of this workshop summary. I find that I have only a single copy left, and would like to file it with the Defense Technical Information Service (DTIC) to make certain that it will remain available to requestors.

If you have no objection, we will be happy to do the actual filing if you will be kind enough to approve the public releasability of the workshop summary.

Thank you for the kind attention I am certain this request will receive.

Sincerely yours,

Saul Lavisky

SAUL LAVISKY, Ph.D.
Vice President and Secretary

Approved -
John D. Fletcher
28 July 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An invitational workshop on front-end analysis of emerging systems was conducted in September, 1979, by HumRRO for the Defense Advanced Research Projects Agency (DARPA). The workshop achieved the following goals:

1. To educate the manpower, personnel, and training (MP&T) research and development community in the process of systems acquisition and of their responsibilities to that process.

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2. To exchange information between and within the Services on ongoing efforts to apply FEA to systems acquisition.

3. To stimulate development of an informal master plan for R&D to improve our ability to perform FEA.

4. To permit informal contacts to be made between system project officers, MP&T research and development personnel, and individuals at various management levels in the civilian and military communities.

This report summarizes the major points covered by the workshop presentations and subsequent discussions. In addition, it lists recommendations that would support the implementation of front-end analyses and produce a comprehensive R&D program in this area.

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FRONT-END ANALYSIS TO AID EMERGING TRAINING SYSTEMS

Workshop Summary

I. INTRODUCTION

An invitational workshop on front-end analysis of emerging systems was conducted on September 10-14, 1979, by HumRRO under Contract MDA 903-78-C-0023 to the Defense Advanced Research Projects Agency (DARPA). The agenda was developed by a workshop steering committee (see Appendix A for the list of Steering Committee members). These individuals were responsible for selecting the issues to be covered at the workshop, presenters of technical papers, discussants, and other workshop participants.[1]

This report summaries the major points covered by the presentations and subsequent discussions. In addition, the final section lists recommendations that would support the current implementation of front-end analyses, and produce a comprehensive R&D program to improve our ability to conduct such analyses as identified by workshop participants.

Definition of Front-End Analysis (FEA)

The definition of FEA presented below resulted from the workshop and follow-up communications with attendees.

> Front-end analysis (FEA) is a process that evaluates requirements for manpower, personnel and training (MP&T) during the early stages of the military systems acquisition cycle. Its purpose is to (1) determine manpower, personnel, and training (MP&T) requirements under alternative system concepts and designs, and (2) estimate the impact of these MP&T requirements on system effectiveness and life-cycle costs. Its end-product should be the information needed to assume that effective resources (human, equipment, materiel) will be available when and as required for each system to achieve its intended contribution to military readiness and effectiveness.

[1] A list of all workshop participants is presented as Appendix A.

Purpose of the Workshop

The goals of the workshop were:

1. To educate the manpower, personnel, and training (MP&T) research and development community in the process of systems acquisition and of their responsibilities to that process.

2. To exchange information between and within the Services on ongoing efforts to apply FEA to systems acquisition.

3. To stimulate development of an informal master plan for R&D to improve our ability to perform FEA.

4. To permit informal contacts to be made between system project officers, MP&T research and development personnel, and individuals at various management levels in the civilian and military communities.

II. PRESENTATIONS/DISCUSSIONS: MAJOR POINTS

Some of the major points derived from the presentations and discussions are described in this section.[2] Three papers provided examples of different types of systems acquisition: an existing system, an emerging system, and a "non-system" (acquisition of equipment for which there is no Project Manager). Four papers examined the methodologies and tools that exist at present for aiding front-end analysis (FEA): the Air Force Logistics Composite Model (LCOM), the Navy HARDMAN methodology, the Army Personnel Affordability program, and the NAVAIR/NTEC front-end analysis process. These presentations set the stage for subsequent information exchange led by designated discussants (see Appendix A for list of Presenters and Discussants).

[2]Copies of the full papers and/or visuals employed at this workshop are available at HumRRO and the Cybernetics Technology Office, DARPA.

A. *EXISTING SYSTEM: AIR FORCE*

- The F-16 aircraft program was a complex procurement involving 4400 vendors and five different countries. There were major problems in determining training requirements and in obtaining training devices in a timely manner. These problems were due, in part, to the following:

    - Only 3 months (of the 9-12 required) were allocated for a task and skill analysis for this complex system.
    - The aircraft configuration was continually changing during this period.
    - Although deficiencies in the prototype aircraft were being corrected, timely delivery of data regarding these changes did not occur.

    As a result, interim training devices were inadequate. This led to the expenditure of enormous numbers of hours for training in the actual aircraft which would have been accomplished in flight simulators.

- The lessons learned from the F-16 program were as follows:

    - One cannot create the training devices/simulators and software until the aircraft design has been stabilized.
    - Incorporating weapon system changes made during development into training devices/simulators necessitates a delay in deliveries of effective flight simulators.
    - There is a strong need for interim trainers that can accommodate systems changes as needed until it is feasible to deliver production-type simulators. This statement recognizes that the goal of OMB Circular A-109 and DoD Directives 5000.1 and 5000.2 are to adequately define training devices at the front end. However, it is a fact of life that the training devices will lag the development of the weapon system.

- <u>Problem facing system program managers</u>. With the occurrence of frequent changes in equipment design, how can we get data on actual equipment to simulator designers so that appropriately designed training devices and simulators are developed and fielded in a timely manner?

Discussion Points

- Training is only a part of the major issue which is life-cycle support. Specific readiness issues and shortfalls must be identified early on. There is a need to determine MP&T requirements as part of the acquisition process at DSARC Milestone 0, thereby providing more adequate FEA.

- OMB Circular A-109, and DoD Directives 5000.1 and 5000.2, which have recently been revised, are written to put the force of DoD policy behind the timely application of FEA.

Notes

OMB Circular A-109. This circular establishes standard policies to be followed by executive branch agencies in the acquisition process including matters related to manpower, personnel, and training (MP&T). A-109 applies to all programs of acquisition even though a system may be one of a kind or the agency concerned is only involved in developing demonstration hardware. Needs and program objectives are henceforth to be expressed in mission terms, and emphasis is given to initial activities of the system acquisition process to permit competitive exploration of alternative system concepts relevant to those mission needs.

DoD Directive 5000.1 (currently under revision). The provisions of this directive apply to the acquisition of major systems within the Department of Defense. The principles in this directive should also be applied, where appropriate, to the acquisition of systems not designated as "major," i.e., less than $100 million. Responsibility for management of system acquisition programs shall be decentralized to DoD components, except for decisions retained by the Secretary of Defense.

The objectives of the directive apply to each DoD official who has direct or indirect responsibility for the acquisition process. These officials shall make every effort to:

1. Ensure that an effective and efficient acquisition strategy is developed and tailored to each system acquisition program.
2. Minimize the time from need identification to introduction of each system into operational use.
3. Achieve the most cost-effective balance between acquisition and ownership costs and system effectiveness.
4. Correlate individual program decisions with the Planning, Programming, and Budgeting System (PPBS).
5. Maximize collaboration with United States allies.
6. Integrate support, manpower, and related concerns into the acquisition process.

DoD Directive 5000.2. The purpose of this directive is to provide procedures for DoD use in implementation of DoD Directive 5000.1. It applies to all major systems acquisition of the Office of the Secretary of Defense (OSD), the military departments, the organization of the Joint Chiefs of Staff (OJCS), and the Defense Agencies.

The procedures cover major system designation and listings, required Milestone 0 documentation (the Mission Element Needs Statement), the role and procedures for the DSARC (Defense System Acquisition Review Council). Also covered are the requirements at each program phase for analysis and documentation of efforts related to front-end analysis of manpower, training and logistics requirements. Included as one of the key enclosures of this directive is the outlines for the Mission Element Needs Statement (MENS).

(For detailed descriptions and copies of the documents, the reader is referred to Mr. Russell Shorey, Office of the Secretary of Defense, Manpower, Reserve Affairs and Logistics, The Pentagon, Room 2B323, Washington, DC 20301.)

B. *EMERGING SYSTEM: NAVY*

The acquisition of major weapon systems in accordance with recent OMB directives (A-76 and A-109) has placed increasing emphasis on using mission analysis for early guidance of system development. Implementing this guidance results in a Mission Element Needs Statement (MENS) as a basis for the acquisition strategy of the program manager. In the case of the VTX Training System (VTXTS), the mission analysis becomes part of the front-end analysis.

The need for the VTX Training System (VTXTS) came from the realization that current aircraft used by the Navy for Undergraduate Jet Pilot training (T2C and TA4 aircraft) were approaching the end of their life cycles. A new training system is required to address learning objectives for pilot training in the 1980's and beyond. VTXTS will do this by using the Instructional System Development methodology and findings from studies of aircraft projected to be in use in the 1990's (F/A-18, F14, AGE, EA6B, etc.). Hopefully, the generic requirements generated by VTXTS will be integrated into the design and acquisition of new aircraft.

In summary:

- A unique feature of the VTXTS procurement is that it is following the new directive OMB Circular A-109 to the letter. A complete training system, not just a new airplane, is to be procured. The hope in the VTXTS procurement is to use a problem-solving approach to training that will take the form of a system integration effort.

- The VTXTS program is an example of the use of mission analysis to guide a weapon systems program during its early phases. The mission analysis culminated in an FEA which is viewed as a continuing process prior to the

procurement of hardware. Initial baseline data will be refined and validated throughout the conceptual and demonstration phases. This is a unique start for procurement of a major program.

- The Navy sees a unique opportunity in the VTXTS to address the design of a total training system and reap the benefits of having all major elements of the system optimized to fulfill the mission requirement, i.e., a complete training system rather than the procurement of a new training airplane. A major issue remains, however, and that is whether to insist on early design freeze or to build more complicated training systems that are sufficiently flexible to accommodate design changes.

C. NON-SYSTEM PROCUREMENT: ARMY

- The development of training systems in the Army requires interactions among three separate commands: TRADOC (Training and Doctrine Command)--responsible for the generation of training theory, doctrine, and systems--initiates the training system requirement; DARCOM (Army Materiel Development and Readiness Command)--develops the Army's equipment; and the field commands--who represent all the soldiers in the field and, therefore, the ultimate users.

- Non-system devices support general military training, two or more systems, or several different types of equipment. PM TRADE is the primary user of front-end analysis (FEA) for non-system acquisitions.

- Training device development in the Army is complicated by the fact that a number of major subordinate commands under DARCOM may act as individual

materiel development agencies, procuring devices to satisfy their own training needs without overall coordination.[3]

- Problems in the Army's procurement process for non-system trainers include the following:
  - Early front-end analyses have not been performed.
  - Training devices are needed before the total training system has been determined.
  - In the development of devices, fidelity is emphasized rather than training effectiveness.
  - Neither training effectiveness nor the value of training effectiveness has been quantified.

Discussion Points

- Problems and issues described above regarding the Army's procedure for non-system procurement did not distinguish between existing and new systems. With regard to existing systems, "rear end" analyses (i.e., using field data as feedback in an interactive process) help in the development of training devices. In fact, the Instructional Systems Development (ISD) process calls for these analyses to be performed and their results to be used as input to training system design and development.

- In many cases, evaluation criteria have not been established and so the effectiveness or benefits that are to be derived from new training devices cannot be properly evaluated.

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[3]This problem was resolved subsequent to the workshop. The Project Manager for Training Devices (PM TRADE) has been assigned responsibility to review and concur with all training device plans.

- Existing simulators have been successfully employed for training before new simulators were available. One use was that of low fidelity, part-task trainers for air-to-air refueling training. In that case, the Air Force rented time on existing simulators. One must try to use existing equipment or existing simulators wherever possible; this may solve the problem discussed earlier, namely, how to make up for the lack of availability of trainers at the time the first aircraft is delivered.

- There is a great need for identifying training and human factors requirements as early as possible in the system's design and development cycle--that is, prior to Milestone 1. Unfortunately, solutions to this problem are currently lacking.

- Training people have not been sensitive to trends in weapon systems design, and they have assumed that weapon system designs are unchangeable.

- The principal issue in front-end analysis is not training but job design. Skill level estimates should be determined from job design data and then checked against a skills inventory. There is a need to develop skills inventories and a system to manage such skill inventories once they are developed.

D. CONCEPTUAL LEVEL: LCOM (AIR FORCE)

- LCOM stands for "Logistics Composite Model," developed by The Rand Corporation for the Air Force. It gives point estimates of needs and refers to maintenance manpower modeling. In the Air Force, LCOM is the major one of 10 separate FEA activities going on simultaneously. This conceptual framework draws upon additional techniques such as the following:

  - Human Engineering analyses
  - Integrated logistics system (ILS)
  - Product performance feedback system

- Instructional systems development (ISD)
- Job guide development
- Human resources design option decision trees
- System ownership cost models
- Consolidated data base
- Occupational analysis

- Logistics and human resources are tightly interwoven and the LCOM model provides a basis for determining life-cycle costing and tradeoffs among the various human or equipment resources. It draws upon task analysis information, job guides, simulation of failure rate, flying hours involved, and, in general, draws upon many of the existing and emerging technologies in order to perform an appropriate man-machine analysis for life-cycle costing.

- Many emerging technologies should be taken advantage of in performing front-end analyses (FEA). One such model, Life Cycle Costing Model (LCCM), runs on a large computer and is used to identify "hot" spots (why so many people, needs for spares, etc.). However, it also takes hours to run. Briefer, more efficient versions of this model are needed.

- The data base for given equipment has to exist before these computer models can be run. This should not be too difficult because 75% of "new" hardware systems already exist and just need to be upgraded, rather than created as totally new systems.

Discussion Points

- Even in new systems, there is a dependence on laboratory data from the manufacturers in order to get reliability and maintainability information.

- Tools, as represented by LCOM, are available for FEA but one problem is that the military does not follow these "models." These models should be consolidated, they should be validated and improved, and a methodology for selecting them should be developed.

E. EQUIPMENT INTENSIVE LEVEL: HARDMAN (NAVY)

- The HARDMAN project (Hardware vs. Manpower) was initiated by the Navy to provide a methodology to adequately consider the implications resulting from weapon system design decisions upon manpower, personnel, and training (MP&T). In 1977, the HARDMAN study found that inadequate attention was being paid to manpower costs throughout the weapon system acquisition process. Most manpower and training plans occur late in the cycle and require costly reprogramming because of a lack of incentives for program managers to concentrate on manpower costs, lack of MP&T policy, and lack of assessment tendency for life-cycle support.

- The Navy has tried to integrate MP&T into the weapon system design and acquisition process by means of HARDMAN which has four main objectives:

    - Institute concise procedures to address MP&T requirements consistent with the direction of higher authority.
    - Provide the means of compliance with policy and procedures to the acquisition community.
    - Develop tools and methodologies to assist program managers when considering impact of system design and the acquisition process on MP&T.
    - Provide the Chief of Naval Operations an assessment of MP&T supportability, i.e., affordability and attainability of each new acquisition before major decisions and resource allocations are made.

- Today, the Navy provides the inputs for MP&T after DSARC Milestone 2, and in many instances this is too late. This is definitely too late in the acquisition process to allow for any man-machine tradeoffs. The hope is that with the use of HARDMAN methodology to identify the manpower constraints, and present plans for addressing productivity changes, these inputs can be

made at Milestone 1. By Milestone 2, the tradeoff analyses, vis-a-vis, manpower and design alternatives and the rationales thereof, will have been performed (and will continue through Milestone 3).

- In summary, there are six steps to the HARDMAN methodology:
  - Establish a consolidated data base.
  - Perform a manpower requirements analysis (e.g., indicate the total number of personnel required for the weapons system.
  - Perform a training requirements analysis.
  - Perform a personnel requirements analysis (i.e., a breakdown of needs by ratings or "faces").
  - Provide an impact analysis.
  - Determine the potential tradeoff areas and iterate the methodology.

All of this must happen prior to DSARC Milestone 2. As a goal, HARDMAN should operate in the design phase with a paper system in order to integrate manpower, personnel, and training (MP&T) requirements into the weapon system acquisition process. The methodology can be used throughout the acquisition process to evaluate man-machine tradeoffs, various maintenance concepts, new learning techniques or other types of alternatives submitted to the program manager.

Discussion Points

- One principal problem is how to get a Program Manager to spend money early in the decision process for a HARDMAN-type analysis when he is trying to hold down his costs. A possible answer is that the Program Manager should have support to implement these analyses from Congress, as well as from within the Navy, and at the OSD level within DoD. As it is, Program Managers

typically allocate funds to MP&T support for later use as discretionary funds for spares and engineering changes.

- Another problem is the practical one of having the ability to assess supportability before acquisition decisions are made. The Chief of Naval Operations appears to be the only one who can make this assessment (as currently in the VTXTS program).

F. *LABOR INTENSIVE LEVEL: AFFORDABILITY (ARMY)*

- Personnel affordability is a research program to develop specific techniques to enable tradeoffs with respect to human factors, personnel, training, and hardware requirements early in the life cycle of emerging weapon systems. Two relevant ARI research efforts are: Cost and Training Effectiveness Analysis (CTEA), and the Early Training Estimation System (ETES). CTEA concerns the selection and analysis of training programs within the system life cycle. ETES concerns the development of a task data base during the early conceptual development stages of a system.

- In order to provide an accurate assessment of emerging training systems, there is a need to develop support information and technologies in four areas:

  - Task definition, data base structure, and standardization, both within the Army and across DoD. Task formats need to be established that have task information relevant to automated training development aids and to the software application requirements over the entire instruction development cycle.

  - Research and development dealing with emerging techniques for training development have to be coordinated under a unified Army utilization plan.

  - Methods must be developed for comparison of derived skills and knowledges across Military Occupational Specialties (MOSs).

  - The hardware design process must structure equipment descriptions so as to lead directly to training-compatible task descriptions. This should be accomplished early in the conceptual stage.

- A series of tradeoff decisions must be made early encompassing hardware development and MP&T. Appropriate tradeoff analysis aids have to be developed and refined. In performing training tradeoff analyses, there is a need to determine what the local resource impacts are from the projected program. This means utilizing existing course materials wherever feasible, utilizing automated decision aids within the schools to reduce the training developer workloads, and determining a common descriptive format to link developing concepts with training needs.

- In sum, personnel affordability involves tradeoff decisions stemming from hardware development and the status of the manpower pool to implement that hardware. The input areas are human factors, training, personnel, and the attendant costs related to these efforts. The activities involved include relating aptitude measures to task performance, evaluating the training programs as a function of the life cycle management model stage, and taking into account the transition between hardware concepts and task definitions needed to feed automated training aids.

Discussion Points

- One needs to consider all costs and impacts of alternative training systems during the early stages of the system acquisition process. Such cost and effectiveness data are needed in all Services. One problem to be solved concerns the source of funds needed to do extensive CTEA studies.

G. ON-GOING FRONT-END ANALYSIS: NTEC (NAVY)

- The principal focus of front-end analysis (FEA) at the Naval Training Equipment Center (NTEC) is a set of integrated activities ultimately directed at providing choices among alternative instructional regimens. FEA at NTEC has five steps which form its principal set of activities.

  - Specification of training requirements
  - Establishment of instructional alternatives
  - Cost analysis of each alternative
  - Evaluation of the effectiveness of each alternative
  - Selection of the most cost-effective alternative

An additional characteristic of this version of FEA is the iterative process needed to refine the data throughout the system's entire life cycle.

- In establishing training requirements for a system, one must distinguish between the constraint-free or ideal environment versus that of the real world which has a number of constraints placed upon it. The NAVAIR/NTEC ISD model was described as a pragmatic ideal.

- One of the analytic approaches used at NTEC is to develop a generic data base of tasks. The steps in this process are: work from existing systems' task inventories to establish a common or generic data base of tasks; develop, from these data, generalized training requirements for a given class of systems; and also provide, as a result of this generic data base of tasks, a baseline for future systems analysis.

- As one is able to increase the specificity of the generic task data base and the specificity of the levels of instructional regimens, then one can continue to refine the entire process of FEA.

- A major problem is the lack of an approach for specifying training media alternatives and iteratively improving upon those choices in FEA.

Discussion Points

- In ISD we do not describe adequately, or in a timely manner, how to determine and select simulator cost and fidelity characteristics needed to make simulators effective for training.

- One problem is obtaining user acceptance without assuming that the type of training equipment specified by the user (often a high fidelity simulator) is necessarily most cost-effective.

Discussion Points Concerning All Service Methodologies

- There are major differences among the Service efforts in maturity of effort, level of detail, and applicability.

- There is a substantial need for standardized definitions of such terms as task analysis, measures of effectiveness, measures of cost, and transfer of training.

- The Services have substantial information about FEA. This information should be compiled and made more available.

- No FEA's have been validated.

- Managerial and institutional aspects of FEA deserve more attention. The incentives for Program Managers to identify roles for R&D managers and training developers should be recognized and strengthened.

III. WORKING GROUP SESSIONS

The participants were divided into three working groups, each of which was to discuss the same six issues, and then report their conclusions to the entire workshop. These six issues were:

- Characterize what an effective, practicable FEA technology should be--including a definition of what FEA is, what the essential components of FEA are, and how results of FEA should be reported.
- List specific technologies we have that can be used now to contribute to the FEA process.
- List specific results/accomplishments that the MP&T community ought to achieve in the next 2 years in support of FEA.
- List specific results/accomplishments that the MP&T community ought to achieve in the next 5-7 years in support of FEA.
- Recommend specific follow-on actions that should occur to produce value from this Workshop.
- Recommend specific actions that should occur to establish FEA as an essential component of the systems acquisition process.

Working group summaries were prepared and distributed at the Workshop. (The working group leaders, whose significant contributions are acknowledged and appreciated, are listed in Appendix A. The complete working group summaries are reported in Appendix B.)

The first issue concerned defining front-end analysis, and the results of these discussions were incorporated in the definition presented on page 1. Similarly, the recommendations for further research are summarized in Section IV, pages 24-26.

1. Define Front-End Analysis (FEA).

A temporal perspective needs to be added to the definition of FEA. FEA occurs up through, but not later than, Milestone 2 in the acquisition process. The initial stage of FEA is a conceptual study designed principally to influence the design of those aspects of the weapon system which affect

manpower, personnel and training on a life-cycle basis (i.e., contribute to weapon system concepts and requirements, to the support concepts, to personnel performance requirements, and to the training subsystem requirements). The second stage of FEA is designed principally to influence the development of the training subsystem, based on such models as ISD. The products at the end of both FEA stages will usually be statements of requirements. These include: manpower requirements (including numbers and spaces); personnel requirements (specific types of people and skills); training requirements; selection and recruitment; and costs (including costs of acquisition, recurring costs, and facilities). The specificity and depth of the front-end analyses (FEA) will depend upon when in the weapon system development cycle the study is done. In the earliest conceptual stages, the analyses will be approximate and general. With iteration, details and depth will evolve, but all analyses should be completed by DSARC Milestone 2.

The results of the FEA should be reported to the Program Manager in terms that would permit a choice of alternative systems depending upon relative costs and risks and should include the constraints and tradeoffs operating in each alternative concept or design proposed.

2. List the specific technologies we now have that can be used to contribute to the FEA process.

Five specific technologies emerged from these discussions:

a. Computers. Data bases, such as job/task/skill inventories, which exist now can be placed in a computerized form. Also, there are computer-based simulation techniques and manpower models currently in use. These computer simulations or models need to be improved and validated to increase their predictive capabilities.

b. Costing Models/Techniques. Costing models and techniques exist which can enhance FEA. For example, COEA and CTEA models have been developed and applied in the Army. There are also econometric models, accounting/budget models, and life cycle cost models which can be used during the conduct of FEA.

c. Training System Development Models/Aids (TRAMOD). Models such as ISD need refinement and amplification. ISD falls short in describing the training device/simulator selection process, but this could be improved. Also, there are tools, such as TRAMOD, which help determine training requirements from the results of a task analysis.

d. Testing and Evaluation. It was suggested that FEA could benefit from comparability analyses of new systems with old by examining historical data of various systems. These data can be obtained from tests and evaluations such as design tests, operational tests, and unit readiness measures, all of which could contribute to FEA.

e. Job Aids. Existing guides and handbooks can be improved to provide better information for both engineers/designers and Program Managers throughout the entire acquisition process.

3. List the specific results/accomplishments that the Manpower, Personnel and Training (MP&T) research community ought to achieve in the next two years in support of FEA.

There is a need to develop better cost data and better cost models, with examples and guidance on how to use the data and models, particularly as they refer to critical factors in FEA.

Also needed are operational definitions of the inputs, processes, and outputs of FEA. A common understanding of FEA terminology will require a set of operationally defined measures. If this is accomplished properly, all

Services will be able to use common data bases in their analyses. This will also permit using cost-effectiveness data to study alternative system feasibility, as well as being able to "fine tune" systems. Standardization and operationalization will also permit better integration of established ISD methodology within the total FEA process. It will allow the development of a more general metric for training requirements than is currently in use. It will also permit the identification of critical factors (i.e., the "drivers," and "big payoff" areas, etc.) which are the important forces behind the results of typical FEAs. We will also be able to assess the state of the data bases--identifying gaps in the data base and problems in its utilization.

One major gap in the data base is information regarding maintenance training, maintenance performance, maintainability, etc. For example, in existing systems, a major improvement in maintenance performance is believed to be feasible and should be a goal of FEA. This could be accomplished if there was a concurrent development of guidelines for quality assurance procedures on FEA components, and methods for precise specification of system performance factors associated with the human component. The latter will probably involve new methods for skill level determination and new methods by which users can better identify training needs.

4. List the specific results/accomplishments that the MPT research community ought to achieve in the next 5 to 7 years in support of FEA.

We need better prediction models for relating options in early weapon system design to MP&T; work should continue on aggregate manpower models. There should be a continuing development of computerized models to assist in the system design relative to MP&T. More work is also needed to assess the validity of MP&T predictions so that further modifications of these models can be accomplished.

There should be a continuous identification process of user training needs. In this regard, there needs to be a skills inventory and population quality census (e.g., an identification of the distribution of aptitudes within the manpower pool, such as project TALENT).

In order to implement all of the requirements noted above, there is a need to develop, or continue to refine, a computerized management information system (perhaps implemented on the ARPANET). This should involve the three Services so that they all could provide and make available data required for FEA.

Job aids in the area of MP&T for Program Managers need to be developed such as handbooks and guides. In addition, efforts are needed to improve awareness of and use of MPT problem-solving capabilities among management personnel, designers, and the R&D community.

5. Recommend specific follow-on actions to produce value from the workshop.

Involve the Program Managers more fully in the entire FEA process. More Program Managers need to be involved in a follow-up workshop of this kind. Also, a curriculum on FEA should be developed and implemented for Program Managers (possibly at the Defense Systems Management College, Ft. Belvoir, Virginia).

More dialogue between management personnel, users, and designers is needed to insure that the results of FEAs would be made available in time to effect the design of new or emerging weapon systems.

The results of the workshop need to be integrated into a presentation and a plan for use by R&D management personnel to publicize the needs for and capabilities to perform FEA in support of weapon system development. A tri-Service list of available technologies should be assembled in some standardized form for distribution throughout DoD.

6. Recommend specific actions that should occur to help ensure establishment of FEA as an essential component of the systems acquisition process.

There is a need to establish an action office or advocate in the DoD to help make the FEA process work. In order to establish this advocacy role, RDT&E funding should be made available to insure that data and findings with respect to FEA are used in activities related to the DSARC process. As part of this effort, there is a need to advise and inform Program Managers and all other decision makers about the impact that FEA on MP&T can have on total DoD requirements.

There is a need to assure stability of personnel as it applies to continuity of the FEA process. If there is too much rotation of key personnel, then FEA started by some individuals will not be continued in the same way by others. In general, stability in assignments is needed for personnel involved in large system acquisitions.

FEA can become an essential component of the systems acquisition process if existing regulations such as OMB Circular A-109, DoD Directives 5000.1 and 5000.2 are implemented and enforced. In this regard, it was recommended that FEA job aids be developed and provided to Program Managers. In addition, requirements for accountability on the part of Program Managers are necessary to ensure FEA implementation, as well as incentives for contractors to perform adequate FEAs.

Concluding Discussion Points--Full Workshop

- The need to identify and compile existing FEA work in the Services was reiterated and emphasized as was the need to validate existing FEA's. There is a need to improve low cost models with major attention to the amount of detail required.

- FEA should be driven by threat and need. We must be able to assess the current position.

- Low cost simulators deserve high priority. In general, we need better kinds of simulation.

- Validation of FEA will require validation of personnel selection and classification procedures. An aptitude and skills inventory should be developed and maintained.

- The need to standardize FEA terms was reiterated and emphasized.

- There should be an OSD action officer for FEA.

- A briefing on FEA should be developed for OSD managers, Congress, Program Managers, and training developers.

- Authorizing directives for FEA now exist. They should be implemented and followed. The most important of these are Directives 5000.1, 5000.2 and 5000.39. The MENS (Mission Element Needs Statement), the Decision Coordinating Paper (which serves as a charter for the Program Manager), and the Integrated Program Summary, Annex D (which is the manpower annex), the manpower requirements document, the logistic support analysis--all require documentation of an FEA in one form or another. The demand for a structured analysis exists. The problem is to produce quality analysis.

IV. RECOMMENDATIONS

As a result of the working group discussions, recommendations for future actions regarding FEA were generated. These were subsequently organized into 15 recommendations and mailed to the workshop participants. Twelve respondents provided additional information concerning the relative importance of these recommendations. The highest priority was given to the recommendation for a plan or a "roadmap" to develop a standardized technology for FEA with heavy emphasis on validation. Similarly, a large number of respondents thought that there is a need to specify the detail required for analytical purposes in the MP&T area for FEA at Milestones 0, 1 and 2. On the other hand, the respondents agreed that it would be relatively unimportant to obtain FEA information from other countries for purpose of comparison. The remaining recommendations were viewed to be appropriate but with not much agreement on their relative importance. All 15 recommendations have been categorized below in terms of whether they concern matters of policy or the conduct of future R&D.

Recommendations: Policy Actions

1. Produce a plan, or "roadmap," that prioritizes what must be done to produce a usable, standardized technology for front-end analysis.

2. Establish uniformity in existing manpower, personnel, and training (MP&T) guidance, reporting, and data base collection and classification. The first step would be to collect existing Service and DoD documents (e.g., the TRADOC training affordability handbook, a data-task analysis handbook, a glossary of standardized FEA terms, universal computer program packages covering frequently used FEA techniques, etc.). The second step would be to develop and publish understandable pamphlets and workbooks for FEA aimed at practitioners with pointers to more detailed references ("cookbook").

3. Begin to institute the management-user-designer dialogue, for example, through follow-on workshops that would include the Program Managers as primary participants (e.g., conduct such a follow-on workshop in about 8 months).

4. Identify who should have the ressponsibility to perform the follow-up R&D and management actions noted herein (other than DARPA). For example, identify an OSD action officer, supported perhaps by a small working group, with budget and authority to perform these actions.

5. Develop and conduct briefings/presentations to top DoD and Congresssional officials on the need for and potential benefits of FEA and a description of a program to achieve these goals.

Recommendations: R&D Actions

1. Obtain data on how selected major training systems were developed to identify critical issues that affected design, availability, and cost of trainers and training (e.g., the F-16, the B-52 refueling trainer fly-off, etc.).

2. Identify areas where more data and/or information (to aid in FEA or to guide the conduct of FEA) are needed. Sources for this might be case studies of MP&T factors in recent DSARC reviews (e.g., the XM-1, the ES-111, ROLAND, LAMPS, etc.).

3. Describe the current state-of-the-art in FEA (generate an annotated list of available technologies), and define the requirement for new R&D. One primary source could be findings of preconceptual studies done on the VTXTS.

4. Generate a tri-Service list of on-going activities concerned with the development of FEA.

5. Establish criteria by which to evaluate the capabilities of existing engineering simulators to validate training requirements early (especially prior to delivery of complex and costly simulators).

6. Simplify the LCOM type models in initial analyses of MP&T and develop other prediction techniques.

7. Specify the amount of detail required for analytical purposes in the MP&T area at Milestones 0, 1 and 2. For example, develop methods for more precise quantitative specification of system performance factors associated with the human component. A second example would be to develop useful and agreed-upon operational definitions and measures of training system costs and effectiveness suitable for varied stages of FEA application. Third, develop a methodology for simple, low-cost means of generating audit trails during the course of FEA. Fourth, prepare a guide for Program Managers which would include data-item descriptions for data impacting MP&T during each phase of the acquisition process. Fifth, establish a means or mechanism for collection, dissemination and utilization of such documentation.

8. Identify distribution of aptitudes in the population to input to a DoD requirements/skills inventory comparison (e.g., Project TALENT).

9. Develop Service-specific instructions for Program Managers on methodology, applications, and benefits of FEA, and include in curriculum of DoD Program Manager's Course at the Defense Systems Management College.

10. Obtain information on how FEAs are performed in other countries.

Appendix A

Workshop Attendees

Steering Committee

CDR. Paul Chatelier
Military Assistant for Training and Personnel Technology
USDRE (Room 3D129)
The Pentagon
Washington, D.C. 20301

Dr. Dexter Fletcher
Program Manager
Defense Advanced Research Projects Agency (DARPA)
1400 Wilson Boulevard
Arlington, Va. 22209

Dr. Jesse Orlansky
Science and Technology Division
Institute for Defense Analyses (IDA)
400 Army-Navy Drive
Arlington, Va. 22202

Dr. Robert J. Seidel
Vice President and Director
Eastern Division
Human Resources Research Organization
300 North Washington Street
Alexandria, Va. 22314

Dr. Harold Wagner
Senior Staff Scientist
Human Resources Research Organization
300 North Washington Street
Alexandria, Va. 22314

Presenters

LTC. Rupert (Skeets) Fairfield
Project Support Officer for Training (VTXTS)
Naval Air Systems Command
Code 413D
Washington, D.C. 20361

CDR. Grant D. Fulkerson
Office of the Chief of Naval Operations
Department of the Navy
OPNAV (OP-112C)
Washington, D.C. 20370

CDR. Joseph F. Funaro
Analysis Division
Naval Training Equipment Center
Code N-82
Orlando, Fla. 32813

Dr. Charles C. Jorgensen
Team Chief
Army Research Institute/Field Unit
P. O. Box 6057
Ft. Bliss, Texas 76544

COL. Calvin Markwood
Deputy System Program Director (F-16)
Aeronautical Systems Division
Wright-Patterson Air Force Base
Ohio 45433

Dr. Ross Morgan
Advanced Systems Division
Air Force Human Resources Laboratory
Wright-Patterson Air Force Base
Ohio 45433

Mr. Paul Wampner
Systems Engineer
Office, Project Manager for Training Devices (DRCPM-TND-SE)
Naval Training Equipment Center
Orlando, Fla. 32813

Discussants

CDR. Paul Chatelier
Military Assistant for Training and Personnel Technology
USDRE (Room 3D129)
The Pentagon
Washington, D.C. 20301

Dr. Frederick A. Muckler
Chief Scientist/Vice President
Canyon Research Group
741 Lakefield Road (Suite B)
Westlake Village, Calif. 91361

Dr. Jesse Orlansky
Science and Technology Division
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, Va. 22202

Mr. Samuel Shapiro
Director, Logistics Equipment and Simulators
Boeing Aerospace Company
P. O. Box 3999
Seattle, Wash. 98124

Mr. Russell R. Shorey
Office of the Secretary of Defense
Manpower, Reserve Affairs and Logistics (MRA&L)
Room 2B323
The Pentagon
Washington, D.C. 20301

COL. Henry Taylor
Commandant, Academic Instructors School/
Foreign Officers School
Air Force Air University
Maxwell Air Force Base, Ala. 36112

Working Group Leaders

Working Group I: Mr. Samuel Shapiro
Director, Logistics Equipment and Simulators
Boeing Aerospace Company
P. O. Box 3999
Seattle, Wash. 98124

Working Group II: Dr. James Baker
Chief, Educational Technology and Simulation
Army Research Institute
5001 Eisenhower Avenue
Alexandria, Va. 22333

Working Group III: Dr. Kay Inaba
Chairman/Technical Director
XYZYX Information Corporation
21116 Vanowen Street
Canoga Park, Calif. 91303

Other Participants

Mr. Thomas M. Ansbro
CNET N-5 (Building 679)
Naval Air Station
Pensacola, Fla. 32509

Professor James Arima
Naval Postgraduate School
Code 54Aa
Monterey, Calif. 93940

Dr. Robert A. Bottenberg
Chief, Computational Sciences Division
Air Force Human Resources Laboratory
Brooks, Air Force Base, Tex. 78235

Dr. John Brock
Principal Research Scientist
Man Machine Sciences
Honeywell Systems and Research Center
2600 Ridgeway Parkway
Minneapolis, Minn. 55413

Dr. C. Victor Bunderson
President
WICAT, Inc.
1160 South State Street
Orem, Utah 84057

Dr. Robert Carroll
Army Research Institute
PERI-TR
5001 Eisenhower Avenue
Alexandria, Va. 22333

Dr. James Cronholm
Psychologist
Office, Project Manager for Training Devices (DRCPM-TND-SE)
Naval Training Equipment Center
Orlando, Fla. 32813

Dr. Paul S. Daly
Dean, College of Aviation Technology
Embry-Riddle Aeronautical University
Regional Airport
Daytona Beach, Fla. 32014

Dr. Philip Doughty
Development and Evaluation Associates, Inc.
500 Midtown Plaza
Syracuse, N.Y. 13210

Mr. John Druzbeck
Technical Advisor
Director, Development Center
Marine Corps Development and Education Command
Quantico, Va. 22134

Mr. Thomas K. Elliott
Applied Science Associates, Inc.
Box 158
Valencia, Penn. 16059

Dr. Robert P. Fishburne, Jr.
Manager for Instructional Systems
Human Factors and Training Center
Calspan Corporation
P. O. Box 8043
Norfolk, Va. 23502

Dr. John D. Folley, Jr.
Applied Science Associates, Inc.
Box 158
Valencia, Penn. 16059

Mr. John Goclowski
Dynamics Research Corporation
60 Concord Street
Wilmington, Mass. 01887

CDR. Charles W. Hutchins, Jr.
Naval Air Systems Command
Code AIR340F
Department of the Navy
Washington, D.C. 20361

Mr. John Johnston
Syllogistics, Inc.
7910 Saint Denise Drive
Springfield, Va. 22153

Dr. H. Dewey Kribs
Director
Instructional Science and Development
5059 Newport Avenue (Suite 303)
San Diego, Calif. 92107

CPT. Forrest R. Miller
Office, Chief of Naval Operations
Department of the Navy (OP112C)
Washington, D.C. 20350

COL. Ronald Rabin
Chief, Training Effectiveness Analysis
U.S. TRADOC Systems Analysis Activity
ATT: ATA-TH
White Sands Missile Range, N.M. 88002

Mr. R. J. Schaffer
Senior Program Engineer
D390, B33/L6
McDonnell Aircraft Company
St. Louis, Mo. 63166

Dr. Lorenz Schrenk
Manager, Training Systems
Honeywell Systems and Research Center
Mail Station 2303
2600 Ridgeway Pky, NE
Minneapolis, Minn. 55413

Dr. Manfred Smith
Mathematician
Navy Personnel Research and Development Center (NPRDC)
Code P303
San Diego, Calif. 92152

Mr. Robert R. Swab
Chief, New Business Division
Deputy for Simulators
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base
Ohio 45433

LTC. Bradford L. Walton
Chief, Occupational Research and Analysis Division
Training Development Institute
ATTNG-TDI-ORA (Building 161)
Fort Monroe, Va. 23651

Dr. Gershon Weltman
Perceptronics Inc.
6271 Variel Avenue
Woodland Hills, Calif. 91367

MAJ. Robert B. Wiltshire
Directorate of Training Developments
U.S. Army Signal Center (ATZHTD)
Fort Gordon, Ga. 20905

Appendix B

WORKING GROUP SUMMARIES

The workshop participants were divided into three working groups. Each working group was to discuss the following six issues and then report their conclusions to the entire workshop. The summary reports of each working group are on the following pages.

The issues discussed were:

1. Characterize what an effective, practicable FEA technology should be--including a definition of what FEA is, what the essential components of FEA are, and how results of FEA should be reported.

2. List specific technologies we have that can be used now to contribute to the FEA process.

3. List specific results/accomplishments that the MP&T community ought to achieve in the next 2 years in support of FEA.

4. List specific results/accomplishments that the MP&T community ought to achieve in the next 5-7 years in support of FEA.

5. Recommend specific follow-on actions that should occur to produce value from this workshop.

6. Recommend specific actions that should occur to establish FEA as an essential component of the systems acquisition process.

WORKING GROUP I

Issue 1. FEA Definition

Steps and process during system acquisition cycle which are required for effective and timely application of personnel systems and training technologies to assure the trained and effective human resources availability.

Temperal Perspective

- Up to Milestone II

Methods and Techniques

- Standardized methodologies

Components

- Requirements of the system
- Manpower requirements (numbers, spaces)
- Personnel requirements (faces, skills)
- Training capabilities and skills
- Selection and recruitment
- Costs (acquisition, recurring and facilities)

Reporting to Project Manager

- Manpower and personnel resource requirements (spaces and faces)
- Training requirements
- Equipment and facilities
- Costs
- Availability/obtainability
- Alternative options
    - Leverage items: Cost, risk
- Constraints
- Tradeoffs

Issue 2. Manpower Requirements

Job/Task Skill Analysis

- Industrial engineering techniques
- Simulation techniques
  Manpower models
- Empirical analysis of historical data
- Force planning/managing
- Topline and Topcat (A/F Personnel Plan)

Training

- First phase training analysis (translation of skills/tasks into training requirements).
- Pre-job/task analysis--Phase I
- Post-job/task analysis--Phase II
- ISD
- TRAMOD--Determine training requirements from task analysis

Cost

- Accounting/budget models
- LCC models
- Econometric models

Availability

Computerized data base

Issues 3 & 4 (arranged roughly by category, with rough chronology within category)

Information Acquisition and Dissemination

- Collect and publish data on the bad effects, including higher system costs, of neglecting FEA (*horror stories*).

- Collect and publish a set of case history reports on early and successful implications of FEA (fairy tales).

- Develop and conduct briefings and presentations to top DoD and congressional people demonstrating cost savings and improved effectiveness resulting from FEA methodology.

- Develop and publish one understandable, condensed guidebook to FEA for program managers with pointers to more detailed references (menu).

- Develop and publish an understandable workbook for FEA for practitioners with pointers to more detailed references (cookbook).

Methodology

- Work toward standardization/consolidation of analytical techniques in major FEA component areas.

- Develop lower cost modeling techniques for key FEA factors.

- Develop and promote availability of "universal" computer program packages covering frequently used FEA techniques.

- Provide introduction to analytical computer programs in DoD program managers' course.

- Develop procedures to synthesize quantitative design goals for the following:

a) Desired man-machine performance
b) Manpower requirements
c) Mastery model of human performance
d) Prerequisite model for entering learners
e) Learning productivity with time
f) Cost of human components

- Develop guidelines for integration of established ISD methodology with total FEA process.

- Develop guidelines for quality assurance procedures on FEA components, with particular emphasis on data bases.

- Develop methods for more precise/quantitative specification of system performance factors associated with the human component.

- Consider new visual and procedural methods for front-end analysis aimed at new training delivery systems.

Training Systems and Alternatives

- Carefully re-examine concept of concurrent procurement of final training system and weapon system--ID and evaluate alternative strategies.

- Develop new and more useful principles of learning transfer, including negative transfer and retention.

- Perform more careful examination of capabilities and limitations of embedded training as alternative training method.

- Examine and evaluate novel, low-cost means of training as alternatives to both high-fidelity simulation and usage of operational equipment (e.g., mental rehearsal, visual imagry, 2-D simulation, gaming, etc.).

- Develop useful and agreed-upon definitions and measures of training system effectiveness suitable for varied stages of FEA application.

- Develop more useful categorization of training media and technologies so that novel training alternatives can be more easily identified.

Background Data and Definitions

- Identify existing data base that contributes to early definition of training systems, publish index or catalog.

- Establish practical data base for those performance factors based on current deployment of reference systems.

- Reassess data item descriptions and generate new ones.

- Develop a more general metric for training requirements than the task.

- Identify the critical factors (i.e., drivers, big payoff areas, levers, etc.) driving results of typical FEA's; assess state of data bases relating to these factors; identify lacks in scope and availability of these data bases; move to rectify lack, create new data bases where necessary, and to develop improved methods of utilization.

- Develop methodology for simple, low-cost means of generating audit trails during the course of system FEA; establish mechanism for collection, dissemination, and utilization of such documentation.

Issue 5. Follow-On Actions

- Firm up methodology of reporting to Project Managers.

- Implement recommendations of Issues 3 and 4.

- Integrate results of the workshop into a presentation and plan.

- Consolidate/prioritize efforts identified in Issues 2, 3 and 4.

- Have a follow-up workshop to include Project Managers and their assessment of this workshop.

Issue 6. Recommended Actions

- Existing directives allow for training FEA.

- Educate Project Managers and other decision makers of the value impact of training FEA on total DoD requirements. Include in the curriculum of Project Manager's school.

- Establish an advocacy in DoD for the FEA process.

- Have the advocate take steps necessary to increase R&D funding for FEA on a timely basis.

- Evaluate adequacy of existing data base and methodology. Identify deficiencies and establish a plan to correct these deficiencies.

- Assess the permanency of management assignment problem as it applies to continuity of FEA.

WORKING GROUP II

Issue 1. FEA Definition

FEA is a threat-driven needs analysis. It is an ongoing process producing a series of products. It is initiated at a pre-conceptual stage and continuing on through Milestone 2. Its ultimate goal is the improvement of unit readiness.

Issue 2. Specific Technologies Contributing to FEA

- Computer simulation/modeling
  - Batch mode
  - Man-in-the-loop mode
- Mockups
  - Static
  - Dynamic
- ISD (improved training system approaches)
  - Needs refinement
  - Falls short on device/simulator/generic system selection
- COEA/CTEA
  - Differentiate cost: COEA/CTEA
    Budget cost (line 14-16 in PM budget)
- Ancestral system history
  - Parametric projection
  - Comparability analysis
- Test and evaluation tools
  - Design tests
  - Operational tests
  - Unit readiness measures
- NTC

Issue 3. Accomplishments/Goals: 2 Year Time Frame

- Need DoD level concentrated briefing on the outcome of this.
- Need to identify JPA's for PM's.
- Need to have LSA data requirements laid on to PM's.
- Need "educational program" for DoD PM School.

Issue 4. Accomplishments/Goals: 5-7 Year Time Frame

- Need skills inventory/population quality census (supply).
- Need service requirements/skill inventory
  - Secretary White's August 1978 requirement met (demand).
- Need "Supply-Demand" comparator.
- Need to develop/design a Management Information System (ARPANET-like) to handle these data
  - Tri-Service contributed
  - Tri-Service accessible
- Identify distribution of aptitudes in the manpower pool.
  - "Reinitiate" a Project Talent

Issue 5. Recommended Follow-On Actions

- Need further Tri-Service meeting
  - Six months hence
  - Overlay IHS on LCSMM (Macro I)
  - Overlay ISD on Macro I (Macro II)
  - Shred out Macro II to more refined media selection requirement
- Develop curriculum for PM Course at Defense System Management College, Ft. Belvoir, Virginia.
- Action to implement curriculum in PM School.
- Generation of Tri-Service list of available technologies.

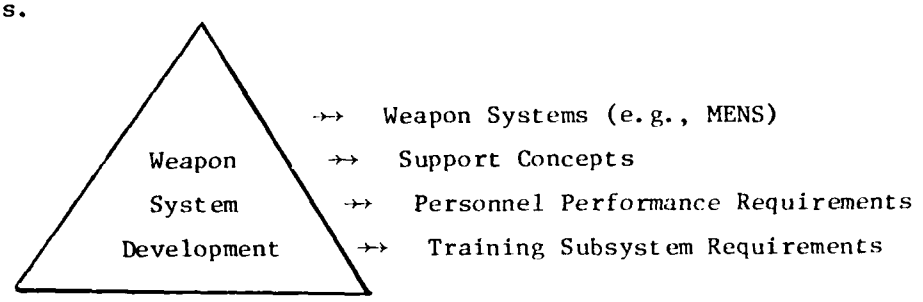
Issue 6. Recommended Actions to Insure FEA is Essential Component of Systems Acquisition Process

- Assume we are at our "milestone zero." Ignore "old ways"--implement new.
- Develop more valid measures of unit readiness to serve as "what if" criteria for PM/TM design decisions.
- Implement existing regulations (109, 5000.1, .2, etc.) with "teeth in them."
  - Have FEA community examine regulations from standpoint of providing PM's with FEA JPA's.
  - Accountability
  - Implement configuration freeze at full scale design review stage.

WORKING GROUP III

Issue 1. Two kinds of front-end analyses (FEA) were distinguished:

1. Concept studies: principally designed to influence the design of the weapon system. These are a part of and will contribute to the sequence of studies: Weapon systems concepts and requirements (e.g., MENS) to the Support concepts to Personnel performance requirements to Training subsystem requirements.



2. Training studies: principally designed to influence the development of the training subsystem including such models as the ISD framework.

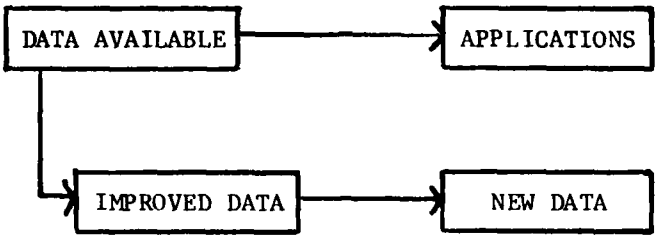
The products of these studies will generally be requirements statements. The specificity and depth of the analysis will depend upon when in the weapon systems development cycle the study is done. In the early stages, the analysis will be gross and general; with iteration, details and depth will evolve.

There was no agreement on a definition of FEA. There was even some question as to whether FEA could be defined. However, there was agreement that certain kinds of analytic products had to be generated at specific times.

Issue 2. The following technologies were noted but with primary emphasis on how they could be improved:

- Data to define critical training parameters.
- Identification of numbers and kinds of people and associated skills.
- Development of handbooks and guides.
- Manpower, Personnel, and Training analyses techniques.
- Prediction techniques for future manpower, personnel and training pools.
- Techniques for early communication with designers.
- Ways of defining what people can really do rather than labels.
- Improvements in cost and performance data bases.
- Guides for engineers on automation.

A basic point was better use of the data already available. The present "data base" is not properly accumulated, assimilated and distributed.



We use our present technology base poorly; we need to spend more time and effort on getting better processing of what we already know.

Issue 3. Next Two Years

- Develop methods by which users can better identify training needs.
- New methods for skill level determination.
- Further work on prototype models for MP&T analyses.
- New methods for aggregation of MP&T demands and supply for future systems.
- Better cost data, better cost models and examples of how to use cost data and cost models.
- Development of technical communication systems between management, users, designers, and R&D communities for MP&T.
- Consolidation of existing training data for better use.
- Operational definitions of inputs, processes, and outputs of FEA.
- Common analysis data bases that can be used by all Services.
- Using cost-effectiveness data apply to fundamental system feasibility studies as well as fine tuning systems.

THE MAJOR SYSTEM EMPHASIS FOR THIS GROUP WAS MAINTENANCE AND MAINTAINABILITY AND MAINTENANCE TRAINING. GOAL: 80% IMPROVEMENT IN MAINTENANCE PERFORMANCE.

Issue 4. Next 5-7 Years

- Extend user training need identification system
- Continue work on aggregation manpower models.
- Continue work on handbook and guides.
- Further development of linkage efforts: MANAGEMENT-USERS-DESIGNERS-R&D
- More meaningful analysis of the R&D community.
- Question assumptions about training.
- Observe and record the validity of MP&T predictions.
- Improved productivity potential of 100% in maintenance performance.
- Continue development of common analysis data base.
- Continue development of computerized models for MP&T in system design.
- Conduct field demonstrations of different maintenance concepts.
- Validate the front-end process in itself.

Issue 5. Specific Follow-On Actions

- Identify an OSD Action Officer (UNANIMOUS VOTE).
- Begin to standardize terms.
- Begin to identify the real technology data base.
- Begin to institute the management-user-designer dialogue.
- Look for new forums for these problems (e.g., the TAGs).
- Appoint small working group to continue work.
- A report from Dr. Fletcher and CDR Chatelier on what they heard in this workshop: good and bad.

Issue 6. Action to Establish FEA

- Develop incentives to contractors for doing FEA.
- Develop job aids on FEA: How should they be done? How described in SOW?
- Keep all informed on MP&T policy for acquisition (e.g., Project HARDMAN).


DATE
ILME